The Coherent Backscattering Opposition Effect: Search for Wavelength Dependent Changes in the Shape of the Phase Curve

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We report the results of very low phase angle measurements ($0.05<\theta<5$ deg) of the opposition effect, the non-linear surge in reflectance seen in particulate materials as phase angle decreases, in a suite of laboratory samples of thirteen discrete particle sizes. The sizes included particles larger and smaller than the wavelength of incident light. These particulate samples are a controlled approximation of a planetary regolith. We compare measurements made at two wavelengths of incident radiation (0.633 microns and 0.543 μm.) in order to search for wavelength dependent changes in the width of the phase curve that are predicted theoretically and observed experimentally in widely spaced particles in liquid suspension (Stephen and Cwilich, 1986: Van Albada et al., 1987.)

At both wavelengths we find that these highly reflective materials exhibit opposition brightnesses approaching 20% at 0.°05 compared to the reflectance observed at 1°. The slope of the phase curve increases with decreasing phase angle all the way to the 0.°05 limit. The circular polarization ratio increases throughout this same measurement range. This behavior is consistent with the observed opposition effect being due to coherent backscattering rather than shadow hiding (Nelson et al., Icarus, in press, 2000).

Models of the coherent backscattering hypothesis predict that the half width at half maximum of the phase curve will vary with incident wavelength, λ, as $\lambda/2\pi D$, where D is the transport mean free path in the medium. Given that the samples were observed at differing wavelengths, we would expect that the observed HWHM would be smaller by about 15% when the samples were observed at the shorter wavelength compared to the longer one. We do not observe this. There may be several explanations for this discrepancy. One possibility is that the particles used in our study, while well sorted, nevertheless have a size distribution about a mean particle size and therefore the change in phase curve width is not as sharp as might be expected were all the particles of exactly the same particle size. Another possibility is that our simulated regolith particles are much more closely packed than those studied in the experimental observations of particles in suspension.

This result may explain the negative report in the Clementine search for a coherent backscattering in the lunar regolith which found an unexpectedly small wavelength dependence of the phase curve of the same lunar regions when observed at two different wavelengths(Buratti et al., 1996). The particle size variance in the lunar soil is far greater than our sorted samples. Measuring the change in the width of the phase curve with wavelength may not be a good test for coherent backscattering in a planetary regolith.

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